NRAP WEBINAR SERIES
WEBINAR #3

Ultrasonic Seismic Wave Elastic Moduli and Attenuation, Petrophysical Models and Work Flows for Better Subsurface Imaging Related to Monitoring of Sequestrated Supercritical CO_2 and Geothermal Energy Exploration

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ABSTRACT

Parameters related to seismic and ultrasonic elastic waves traveling through a porous rock material with compliant pores, cracks and isometric pores, and pore filling fluids are subject to variations that are dependent on petrophysical properties. Experiments simulating subsurface conditions were performed in the Geomechanics and Flow Laboratory at the National Energy Technology Laboratory (NETL) of the United States Department of Energy (DOE) with varied pore-filling fluids, effective pressures (0.01 to 50 MPa), and temperatures (21° to 80° C). Ultrasonic compressive and shear wave VP, VS1 and VS2 velocities were measured using a New England Research (NER) Autolab 1500 device, allowing calculation of the dynamic moduli parameters: Bulk modulus (K), Young's modulus (E), Lamè's first parameter (λ), Shear modulus (G), Poisson's ratio (ν), and P-wave modulus (M)). Using an aluminum reference core and the ultrasonic waveform data collected, we employed the spectral ratio method to estimate the quality factor for the P ultrasonic seismic phase. The quality factor (Qp) is a dimensionless value that represents the attenuation of a seismic wave as it travels through a rock. Carbonate samples were tested dry, using atmospheric gas as the pore phase, as well as saturated with deionized water, oil, and supercritical CO2. Our research indicates framework composition, porosity, heterogeneities, temperature, pressure and pore filling fluids are physical controls on wave attenuation and shifts trends in the Young's Modulus-Poisson's Ratio and λρ-μρ cross plot spaces. The effects of temperature and pressure on elastic attenuation and λρ-μρ are less significant than porosity and rock heterogeneities. The presence of fluids causes a distinct shift in λρ values, an observation which could provide insight into subsurface exploration using amplitude variation with offset (AVO) classification.